

Rocket Experiment Demonstration of a Soft X-ray Polarimeter

Completed Technology Project (2017 - 2021)



Project Introduction

This proposal is the lead proposal. Boston University will submit, via NSPIRES, a Co-I proposal, per instructions for Suborbital proposals for multiple-award. Our scientific goal of the Rocket Experiment Demonstration of a Soft X-ray Polarimeter (REDSoX Polarimeter) is to make the first measurement of the linear X-ray polarization of an extragalactic source in the 0.2-0.8 keV band. The first flight of the REDSoX Polarimeter would target Mk 421, which is commonly modeled as a highly relativistic jet aimed nearly along the line of sight. Such sources are likely to be polarized at a level of 30-60%, so the goal is to obtain a significant detection even if it is as low as 10%. Significant revisions to the models of jets emanating from black holes at the cores of active galaxies would be required if the polarization fraction lower than 10%. We employ multilayer-coated mirrors as Bragg reflectors at the Brewster angle. By matching to the dispersion of a spectrometer, one may take advantage of high multilayer reflectivities and achieve polarization modulation factors over 90%. Using replicated foil mirrors from MSFC and gratings made at MIT, we construct a spectrometer that disperses to three laterally graded multilayer mirrors (LGMLs). The lateral grading changes the wavelength of the Bragg peak for 45 degree reflections linearly across the mirror, matching the dispersion of the spectrometer. By dividing the entrance aperture into six equal sectors, pairs of blazed gratings from opposite sectors are oriented to disperse to the same LGML. The position angles for the LGMLs are 120 degrees to each other. CCD detectors then measure the intensities of the dispersed spectra after reflection and polarizing by the LGMLs, giving the three Stokes parameters needed to determine the source polarization. We will rely on components whose performance has been verified in the laboratory or in space. The CCD detectors are based on Chandra and Suzaku heritage. The mirror fabrication team at MSFC has significant experience with flight systems and five mandrels to be used already exist and the team will fabricate more for this project in order to increase the area of the flight optics. LGMLs have been in development under NASA APRA funding for the past few years and are sufficient for this project. A current APRA grant is funding further development to improve the LGMLs. Prototype gratings for the project have been fabricated at MIT and the development team continues to improve them under separate funding. We have constructed a source of polarized X-rays that operates at a wide range of energies with a selectable polarization angle in the lab for testing prototype components of our proposed instrument. In 2013, we demonstrated that the polarimetry beam-line provides 100% polarized X-rays at 0.525 keV. In 2014, we upgraded the source by installing a mirror with a laterally graded multilayer (LGML) coating, providing a wide energy range. In 2015, we tested new LGMLs with two more material combinations (C/CrCo and La/B4C) in order to obtain higher efficiencies in different soft X-ray bands than our early LGML made of W and B4C. The REDSoX Polarimeter would rotate by 120 degrees about the optical axis in flight in order to assess and remove possible systematic effects. Our technological approach has significant promise for future missions that would operate in the 0.1 to 1.0 keV band. This



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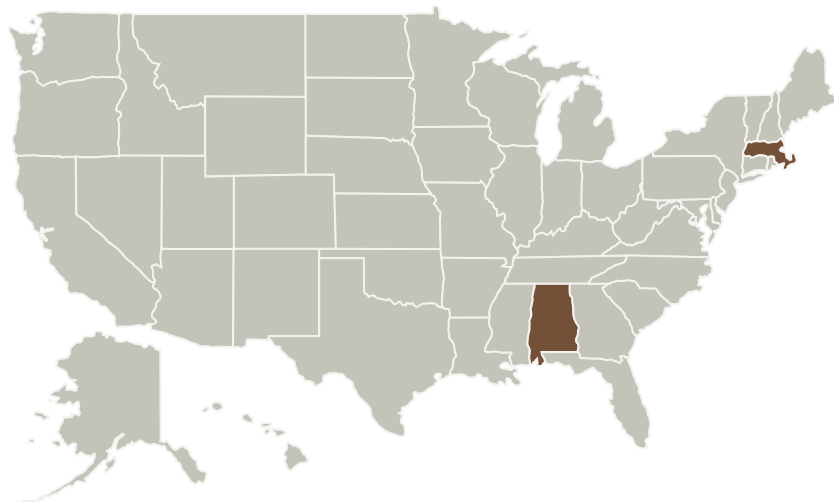


sounding rocket program would provide a demonstration that a multilayer-based polarimetry approach can work, providing a basis for an orbital mission.

Anticipated Benefits

The Astrophysics Research and Analysis program (APRA) supports suborbital and suborbital-class investigations, development of detectors and supporting technology, laboratory astrophysics, and limited ground based observing. Basic research proposals in these areas are solicited for investigations that are relevant to NASA's programs in astronomy and astrophysics, including the entire range of photons, gravitational waves, and particle astrophysics. The emphasis of this solicitation is on technologies and investigations that advance NASA astrophysics missions and goals.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Massachusetts Institute of Technology(MIT)	Lead Organization	Academia	Cambridge, Massachusetts

Primary U.S. Work Locations

Alabama	Massachusetts
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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Massachusetts Institute of Technology (MIT)

Responsible Program:

Astrophysics Research and Analysis

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

Herman L Marshall

Co-Investigators:

Norbert S Schulz
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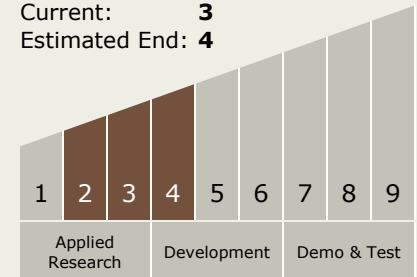
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Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **4**



Technology Areas

Primary:

- TX08 Sensors and Instruments
 - └ TX08.1 Remote Sensing Instruments/Sensors
 - └ TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System